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TAPHONOMIC ANALYSIS ON FOSSILS OF PLEISTOCENE MAMMALS FROM DEPOSITS SUBMERGED ALONG SOUTHERN RIO GRANDE DO SUL COASTAL PLAIN, BRAZIL [1]

(With 15 figures)

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ABSTRACT: The taphonomic history of vertebrate remains is often complex, involving many different phases, which can be better understood by means of multivariate analyses of the taphonomic (biostratinomic and diagenetic) features on the remains. This paper describes the results of an analysis of biostratinomic features on 737 fossils of extinct terrestrial mammals (Pleistocene megafauna) from deposits submerged along the shoreline of Rio Grande do Sul State, southern Brazil. A taphonomic comparison with similar fossils from continental deposits of Chuí creek was also performed. Althought the fossils from deposits submerged along the coast of Rio Grande do Sul State exhibit some distinct physical features (*e.g.*, colour, hardness), as result of exposition of these remains to marine environment, the overall taphonomic similarities between these fossils and those from Chuí creek suggest that both fossil assemblages share a similar origin. The biostratinomic variations observed among the fossils from submarine deposits are result of differential preservation which allow to recognize at least three distinct taphofacies: a) In the foreshore, covered by sediment and subject to erosion and removal during winter storms; b) In biodethritic accumulations associated to topographic highs, also subject to erosion; and c) In deeper areas far from the coastline and not subject to wave action today.

Key words: Taphonomy. Taphofacies. Megafauna. Pleistocene.

RESUMO: Análise tafonômica em fósseis de mamíferos pleistocênicos provenientes de depósitos submersos ao longo do sul da planície costeira do Rio Grande do Sul, Brasil.

A história tafonômica de restos de vertebrados é freqüentemente complexa, envolvendo diversas fases diferentes, que podem ser compreendidas através da análise multivariada das feições tafonômicas (bioestratinômicas e diagenéticas) presentes nesses restos. Este artigo descreve os resultados da análise dos aspectos bioestratinômicos observados em 737 fósseis de mamíferos terrestres extintos (megafauna pleistocênica) provenientes de depósitos submersos o longo da costa do Rio Grande do Sul, Brasil. Foi feita também uma comparação com fósseis similares provenientes dos depósitos continentais do arroio Chuí. Embora os fósseis dos depósitos submersos ao longo da costa apresentem algumas características físicas distintas (e.g. coloração, dureza), resultantes da sua exposição ao ambiente marinho, os aspectos tafonômicos em geral são similares aos fósseis do arroio Chuí, sugerindo que ambas assembléias compartilham uma origem comum. Variações observadas nos aspectos bioestratinômicos dos fósseis dos depósitos submersos são resultado da preservação diferencial, que possibilitam reconhecer ao menos três tafofácies distintas: a) na antepraia, onde os restos estão recobertos por sedimento e sujeitos a erosão e remoção durante tempestades de inverno; b) em concentrações biodetríticas associadas a altos topográficos, também sujeitos a erosão; e c) em áreas mais profundas, longe da costa e atualmente fora da zona de ação das ondas.

Palavras-chave: Tafonomia. Tafofácies. Megafauna. Pleistoceno.

INTRODUCTION

The origin of Rio Grande do Sul coastal plain dates back to Late Pleistocene and was a result of glacio-eustatic sea level fluctuations (TOMAZELLI *et al.*, 2000). These fluctuations originated four extensive barrier-lagoon depositional systems parallell to the coastline (VILLWOCK & TOMAZELLI, 1995).

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The third event, correlated to the maximum transgressive occurred 123 ky BP, according to oxygen isotopic curves (SCHACKLETON & OPDYKE, 1973; IMBRIE *et al.*, 1984), was responsible for the origin of Barrier-Lagoon System III, which is well preserved along the coastal plain. Lacustrine and fluvial deposits associated to this system are very important due to the presence of fossils of terrestrial mammals of Late Pleistocene age (Lujanian Land-Mammal Age, according to the biostratigraphic classification of PASCUAL *et al.*, 1966). Deposits containing these fossils are well known in two main areas along the coastal plain (LOPES, 2006): 1) on ancient fluvial deposits exposed along the banks of Chuí creek; and 2) on submarine deposits, along the foreshore and continental platform, associated to submarine topographic highs (parcels and banks). The distribution of fossiliferous deposits along the coast is uneven, with two areas of higher fossiliferous concentration (BUCHMANN, 1994): Cassino beach, near the estuary of Lagoa dos Patos lagoon, and along the 40km-long beach area known as "Concheiros", located 160km to the south (Fig.1). This uneven distribution seems to be determined by geomorphological features of the pre-Holocene substrate (BUCHMANN & TOMAZELLI, 2001). While these deposits have not yet been directly surveyed, its fossiliferous content is well-known, since many fossils are removed by winter storms and are thrown onto the beach by wave action (Fig.2). Besides fossils of terrestrial mammals, the submarine deposits also contain remains of marine invertebrates (crustaceans and echinoderms) and vertebrates (cetaceans, elasmobranchs and teleosts). Fossils of seabirds (LOPES *et al.*, 2006) and reptiles (HSIOU & FORTIER, 2007) have also been found associated to these deposits.

The fossiliferous deposits of Chuí creek are a result of the accumulation of vertebrate remains in lacustrine and fluvial environments (LOPES *et al.*, 2005a). Althought the exact origin of the submarine deposits found along the foreshore and continental platform is not yet known, the mammalian faunal content allow to establish biostratigraphic correlation with the deposits of Chuí creek, suggesting a similar age for both. The presence of fossils of terrestrial mammals suggest that the submarine deposits were originally continental deposits associated to Barrier-Lagoon System III which were subsequently drown by sea-level transgressions.

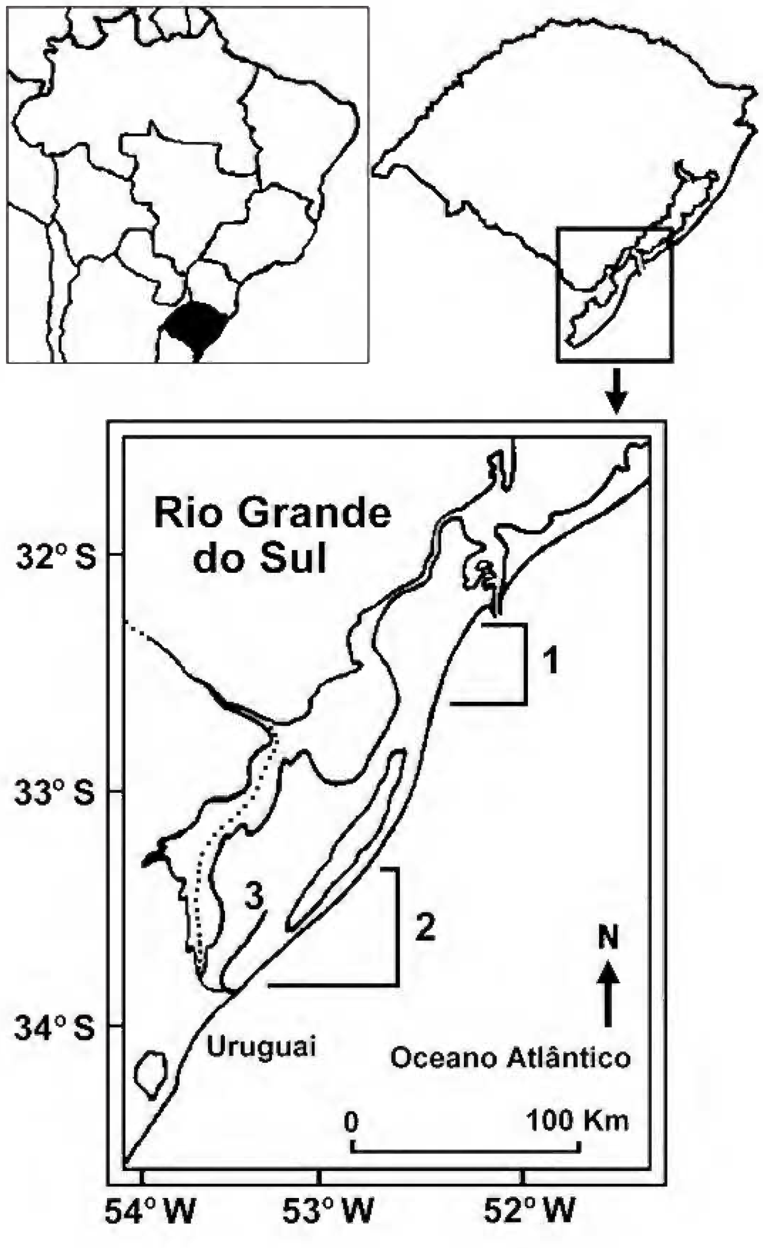


Fig.1- Map of the southern portion of Rio Grande do Sul Coastal Plain showing fossiliferous areas: 1) Cassino beach; 2) Concheiros and 3) Chuí creek.

OBJECTIVES

Since taphonomic features on fossils are determined by physical characteristics of the depositional environment in which were accumulated (SPEYER & BRETT, 1986), the analysis of these features on fossils from the deposits submerged along Rio Grande do Sul coast should provide information regarding the nature and characterisitcs of these deposits.

The main scope of this work is to describe the biostratinomic features on fossils of Pleistocene mammals collected along the coastal plain of Rio Grande do Sul State, in order to evaluate the taphonomic context in which are preserved. Althought the ocurrence of these fossils have been known for decades, the origin of the deposits which contain it, as well as the taphonomic context of these remains are still unknown. The similar fossil content found on these deposits and in those from Chuí creek, suggest that both share a similar origin, thus some taphonomic similarities between these remains should be present. In order to test this hypothesis, a comparison between the biostratinomic features on the fossils from and those from Chuí creek was also performed. These analyses should not only provide information concerning the taphonomic context of the fossils from submerged deposits but should also improve our knowledge regarding the origin and physical characeristics of these deposits.

Fig.2- Fossil of an extinct mammal (in black) as found on the beach, thrown by storm waves.

MATERIAL AND METHODS

The taphonomic analysis described here was carried out on 737 fossil samples from the paleontological collection of Fundação Universidade Federal do Rio Grande (FURG). Most of these fossils were collected between 1990 and 2004, on the coast section between Rio Grande and Chuí, by researchers from FURG and Universidade Federal do Rio Grande do Sul (UFRGS), while others have been donated by fishermen who accidentally collected it on bottom trawlers. Most of the fossils collected on the beach come from the area known as "Concheiros", located about 160km south of Rio Grande, between Albardão lighthouse and Hermenegildo. The Concheiros are roughly 40km long and the beach in this area is characterized by coarser sand, steeper slope and great amount of bioclasts of marine origin (Fig.3).

Fig.3- Detail of the concentration of marine bioclasts at the Concheiros.

In this area, the marine bioclasts and fossils are accumulated by the same coastal physical processes that apparently were responsible for the origin of similar deposits in the past (Lima, 2004). The fossils collected by trawlers came from areas farther from the coast, at distances of 20km and depths between 50 and 100m.

Among the fossils subject to this analysis, all of those that could be positively identified are of Pleistocene herbivores (Tab.1), mainly medium- to large-bodied species, which are also found on deposits along Chuí creek. Small species, such as rodents (Rodrigues, 2003), are known only by teeth. For comparison with remains from Chuí creek, only those of larger species were considered (Tab.2), since small ones are either absent or scarce on this deposit.

According to Behrensmeyer (1991), taphonomic history of vertebrate remains is often complex, involving many different phases during the transition of the remains from biosphere to lithosphere. These phases can be better understood by analysing the taphonomic features on fossils, which allow to compare the remains with those from other deposits. That author proposed a quali-quantitative multivariate analysis method involving several taphonomic parameters observable on fossil remains. This method should provide information regarding biostratinomic processes these remains were subject to, therefore allow to reconstitute the taphonomic history of these remains, and is the same method employed on the analysis of fossils from Chuí creek (Lopes *et al.*, 2004), which should allow comparison between fossils from both assemblages.

The present analysis was based solely on physical characteristics of the fossils, since to date no chemical or isotopic analysis was performed on these remains. The analysis was based upon the following parameters:

1) Physical Integrity - For this analysis, the fossils were divided in three classes:
   - ➢ Complete,
   - ➢ Broken (when more than 50% of the original structure remains)
   - ➢ Fragments (when less than 50% of the structure remains).

2) Cracking - Three distinct stages were recognized:
   - Stage 0: There are no crackings.
   - Stage 1: There are only surface crackings.
   - Stage 2: There are deep crackings, which expose the internal structure of the fossil and may compromise its structural integrity.
3) Surface Abrasion - The fossils were classified either as Abraded or Unabraded.
4) Skeletal Parts - Divided according to Voorhies groups:
   - Group I - Bones easily removed by weak currents (vertebrae, ribs, etc.)
   - Group II - Bones that require higher energy to be removed (humerus, femur, tibia, etc.)
   - Group III - Bones removed only by very strong currents (skull bones, teeth, mandible, etc.).
5) Surface Markings - Present or Absent.
6) Cement - Present or Absent.
7) Colonization by Organisms - Present or Absent.

TABLE 1. Mammalian genera analyzed in this work

Superordem Xenarthra
Ordem Cingulata
Família Dasypodidae
Propraopus
Família Pampatheriidae
Holmesina
Pampatherium
Família Glyptodontidae
Doedicurus
Glyptodon
Hoplophorus
Lomaphorus
Neothoracophorus
Panochthus
Ordem Tardigrada
Família Megatheriidae
Megatherium
Família Mylodontidae
Glossotherium
Lestodon
Mylodon
Ordem Litopterna
Família Macraucheniidae
Macrauchenia
Ordem Notoungulata
Família Toxodontidae
Toxodon
Ordem Rodentia
Família Myocastoridae
Myocastor
Família Caviidae
Cavia
Família Hydrochoeriidae
Hydrochoerus
Ordem Proboscidea
Família Gomphotheriidae
Stegomastodon
Ordem Perissodactyla
Família Equidae
Equus
Hippidion
Família Tapiridae
Tapirus
Ordem Artiodactyla
Família Camelidae
Lama
Palaeolama
Hemiauchenia
Família Cervidae
Morenelaphus
Ozotocerus

TABLE 2. Body mass estimations (from Fariña *et al.*, 1998) of the fossil mammalian taxa from submarine deposits which were compared with those fom Chuí creek.

Taxa		Body Mass(Kg)
Tardigrada: Megatheriidae Mylodontidae	*Megatherium* sp. *Lestodon* sp. *Scelidotherium* sp.	1300-4000
Cingulata: Glyptodontidae	*Glyptodon* sp. *Panochthus* sp.	1100-2000
Artiodactyla: Cervidae	*Blastoceros* sp. *Ozotoceros* sp. *Mazama* sp. *Morenelaphus* sp.	30-100
Perissodactyla: Equidae	*Hippidion* sp. *Equus* sp.	300-600
Notoungulata: Toxodontidae	*Toxodon* sp.	1100
Proboscidea: Gomphotheriidae	*Stegomastodon* sp.	4000

These taphonomic parameters were defined by preliminar observation of the physical aspects of the fossils, and are the same adopted by Lopes *et al.* (2004) on the analysis of fossils from Chuí creek, with the exception of the two last parameters (Cement and Colonization), which are specific of marine environment. The presence of those biostratinomic features is presumably result of the physical characteristics of the depositional environment in which these fossils were originally preserved, and subsequent alteration by re-working on marine environment. Therefore, the analysis of the taphonomic features on these fossils may provide not only information regarding their taphonomic history, but also on the depositional context in which these fossils are preserved today.

RESULTS AND DISCUSSION

The results of this analysis allowed to establish comparisons between the taphonomic features on the fossils from submerged deposits and on fossils from continental deposits exposed along the banks of Chuí creek (Lopes, 2006). The comparison between biostratinomic features on fossils from both assemblages was plotted on a taphogram (Fig.4). The most striking features on the fossils from submerged deposits are the dark colour, ranging from black to reddish, and their extreme hardness, while the fossils from Chuí creek are light-coloured (Fig.5) and more fragile. These physical differences between fossils from Chuí and from submarine deposits are presumably result of the re-working of the latter in marine environment due to sea-level transgressions. The analysis of the biostratinomic features on these fossils provided the following results:

Physical Integrity

Of the 737 fossils analyzed, 33% are fragments, 12% are broken, and 55% are complete.

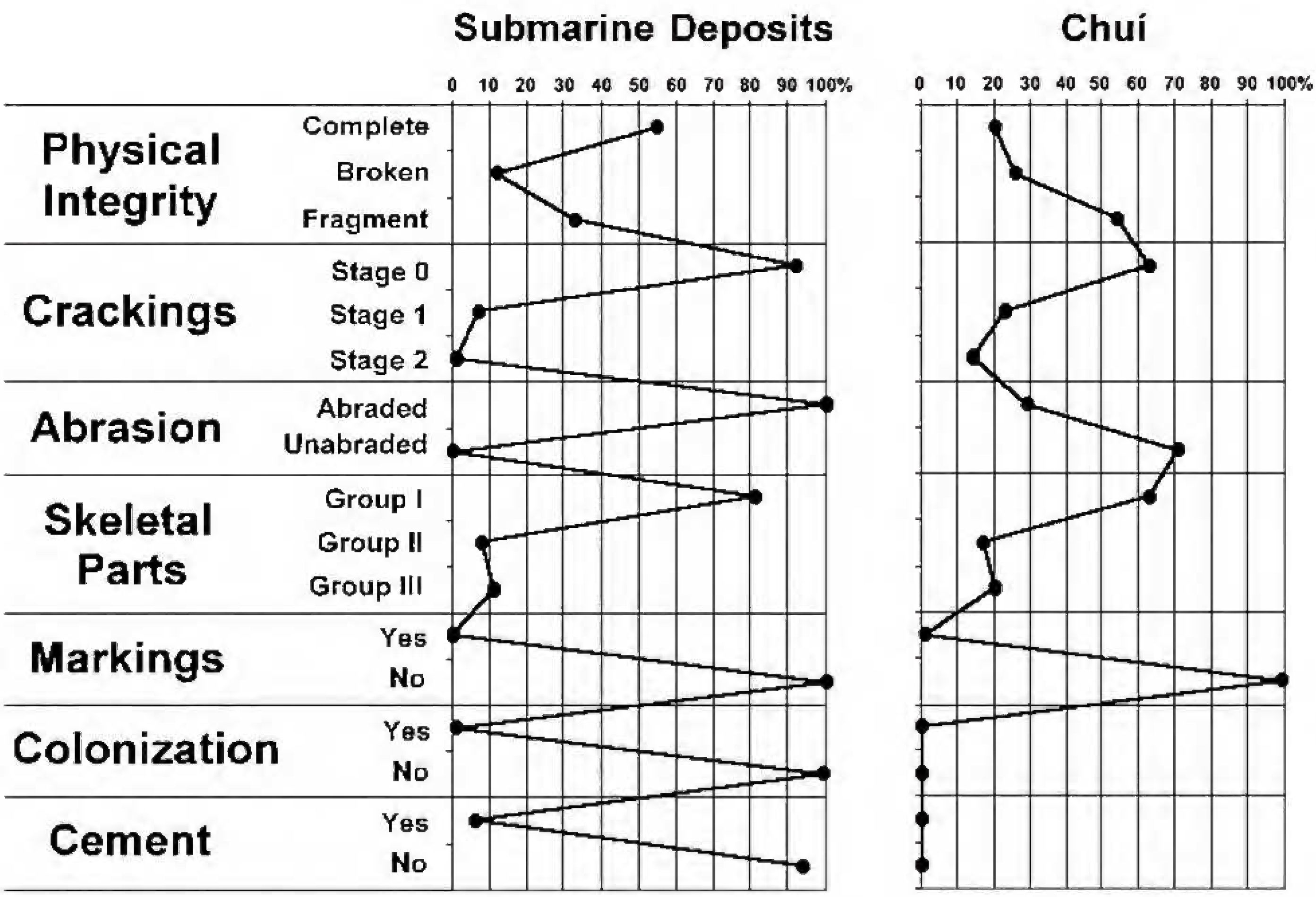


Fig.4- Taphograms comparing results of the analysis of biostratinomic features on fossils from Chuí creek and submarine deposits.

These latter are mainly small elements (about 5cm in length or diameter) such as osteoderms of armadillos (*Pampatherium* sp., *Holmesina* sp., and *Propraopus* sp.) and glyptodonts (*Glyptodon* sp., *Panochthus* sp., and *Doedicurus* sp.), as well as phalanges. Due to its shape and small size these fossils are easily removed and transported by mechanical action of water currents.

The fossils from Chuí creek are mainly small-sized, unidentifiable fragments, which exhibit plain breaking patterns characteristic of post-fossilization breaking (Holz & Simões, 2002), and still have the internal spongy structure preserved, suggesting that were subject to re-working after fossilization, otherwise the soft internal structure of the bones would not have been preserved; among these fossils there is only one conclusive example of pre-fossilization breaking. Among the fossils from submarine deposits, there is no conclusive evidence of breaking prior to fossilization, althought some fossils have lost the internal spongy structure (Fig.6). Most of the broken fossils still have the internal spongy structure preserved (Fig.7), indicating that they were broken after the fossilization.

Fig.5- Comparison between colour on a fossil from Chuí creek (left) and submarine deposits (right). Scale bar = 15cm.

Fig.6- Distal portion of a *Toxodon* femur, without internal spongy structure, probably result of re-working prior to fossilization. Scale bar = 10cm.

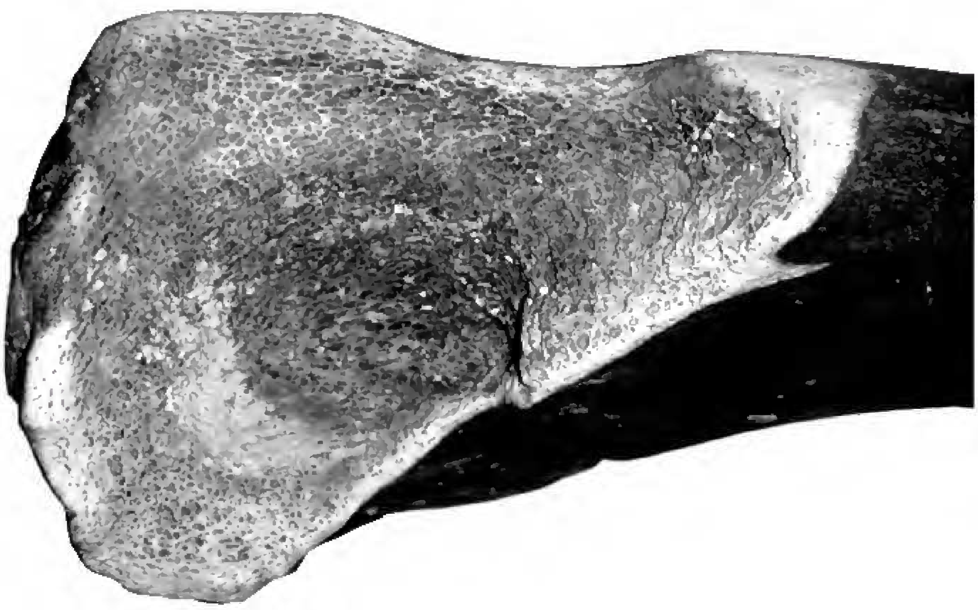


Fig.7- Fossil with preserved internal structure, indicating post-fossilization re-working.

Crackings

Surface crackings on fresh bones are result of weathering and the extension and depth of these features allow to estimate how much time the remains were exposed under subaerial environment prior to deposition (Behrensmeyer, 1978). This author recognized six weathering stages according to the surface crackings observed on fossils. Among the fossils from Chuí creek and submarine deposits, only three cracking stages were recognized.

Only 7.3% of the fossils from submerged deposits exhibit crackings; of these, 88% exhibit Stage 1 crackings, and 12% Stage 2 (Fig.8). The crackings are more evident parallel to the longer axis of long bones, such as femora, humeri and tibiae. Althought crackings on vertebrate bones are result of weathering under subaerial conditions (Behrensmeyer, 1978), in the case of the fossils from submerged deposits these crackings may be result of recrystallization and expansion of the elements permineralized in the bone's structure during the diagenesis in marine environment.

Few fossils from Chuí creek exhibit surface crackings, a pattern similar to those observed among fossils from the submerged deposits. According to Behrensmeyer (1978) bones develop crackings within months of exposure to subaerial environment, thus the relative absence of crackings on fossils from both deposits suggest that the remains were covered by water and/or sediment shortly after death, which prevented weathering.

Surface Abrasion

The degree of surface abrasion on the fossils was measured by the wearing and rounding of the surfaces. The extent and degree of abrasion allowed to classify the fossils either as abraded or unabraded. Among fossils from Chuí creek, only 29% are abraded. The lack of abrasion on these fossils is probably due to their fragility that causes them to break more easily, so cannot withstand the mechanical action of water currents that would cause abrasion. All fossils from submarine deposits show signs of abrasion, and small elements such as phalanges and osteoderms (Fig.9) are more abraded. These elements are lighter and easily removed by waves, thus remaining longer time under the abrasive action of suspended sediments and friction with the bottom in the surf zone. This abrasive action is responsible for the great amount of small (<1cm) and rounded, unidentifiable fossil fragments found along the beach.

Bigger and heavier fossils (*e.g.,* tibiae, femora) exhibit fewer signs of abrasion, and these, when present, are more conspicuous on processes and articular surfaces (Fig.10). This lack of abrasion indicates that bigger fossils are subject to abrasive action of suspended sediment and friction with the bottom for a short time. This, plus the size and weight of these remains, which make their removal possible only under high wave energy conditions (during winter storms), suggest that the source area is not far from the beach, which make the time interval between removal and deposition of these fossils onto the beach relatively short. On the other hand, many small fossils exhibit very abraded and polished surfaces, and there is also a great amount of very rounded centimeter-sized fossil fragments.

Comparisons between fossils from Cassino beach and Concheiros performed by Caron (2004) revealed that those from Cassino are much more rounded and spherical than those from Concheiros, indicating greater re-working probably due to greater distance from source area.

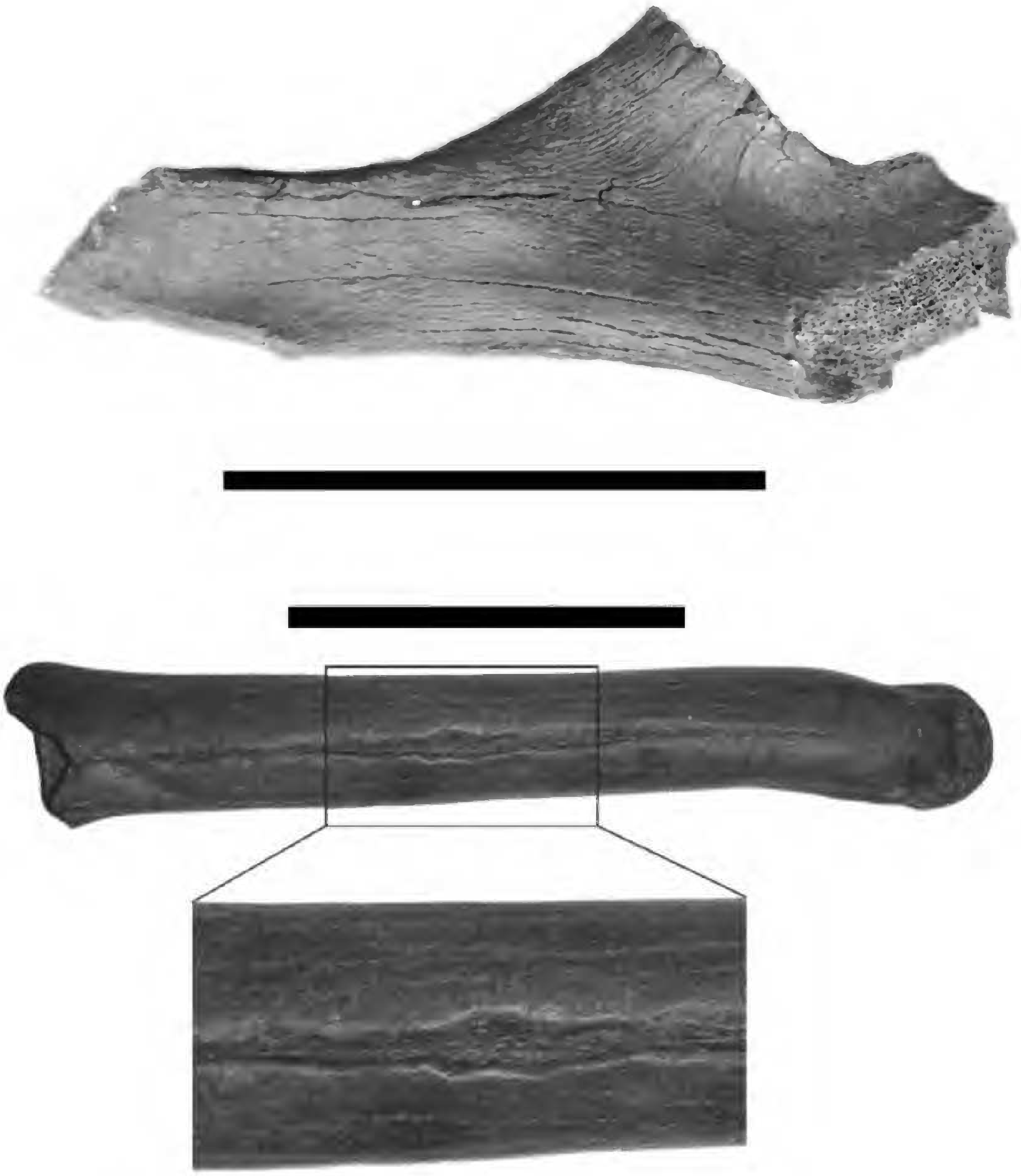


Fig.8- Differences between cracking stages: Stage 1 (top) and Stage 2 (bottom). Scale bars = (a) 20cm; (b) 10cm.

The fossils from Cassino also exhibit a normal size distribution, with modal size between 32 and 64mm. On the other hand, fossils from Concheiros exhibit a bi-modal distribution, with modes comprising fossils of 8 to 16mm and 32 to 64mm (Fig.11). These features allow to divide the fossils from Concheiros in two groups: 1) small (<2cm) fossils that are continuously being abraded, and 2) bigger fossils that are not under constant abrasive action of suspended sediment and/or friction with the bottom.

Skeletal Parts

For the analysis of this parameter, only fossils that could be assigned to Voorhies Groups were considered. The analysis revealed the presence of skeletal parts of the three Groups, being 81% of Group I, 8% of Group II, and 11% of Group III. These proportions are comparable to those observed among the fossils from Chuí creek. This similar pattern suggests that both deposits originated in the same sedimentary context, on fluvial environments in which vertebrate remains were accumulated and re-worked. The presence of articulated skeletal parts (Lopes *et al.*, 2001) among fossils from Chuí creek indicate that some remains were deposited and fossilized in place, while other fossils were removed and transported from source areas located at varying distances.

Surface Markings

None of the fossils analyzed exhibit any surface markings that could conclusively be attributed to biogenic processes such as scavenging, predation or use as human tools. It is possible that these markings, if present, were masked by the re-working of these fossils on marine environment. On the other hand, only three fossils from Chuí creek exhibit surface markings, in the form of thin, parallel grooves, but the origin of these markings could not be conclusively attributed to biogenic processes. The lack of surface marking suggests that the vertebrate remains from these deposits were quickly covered by water and / or sediment soon after death.

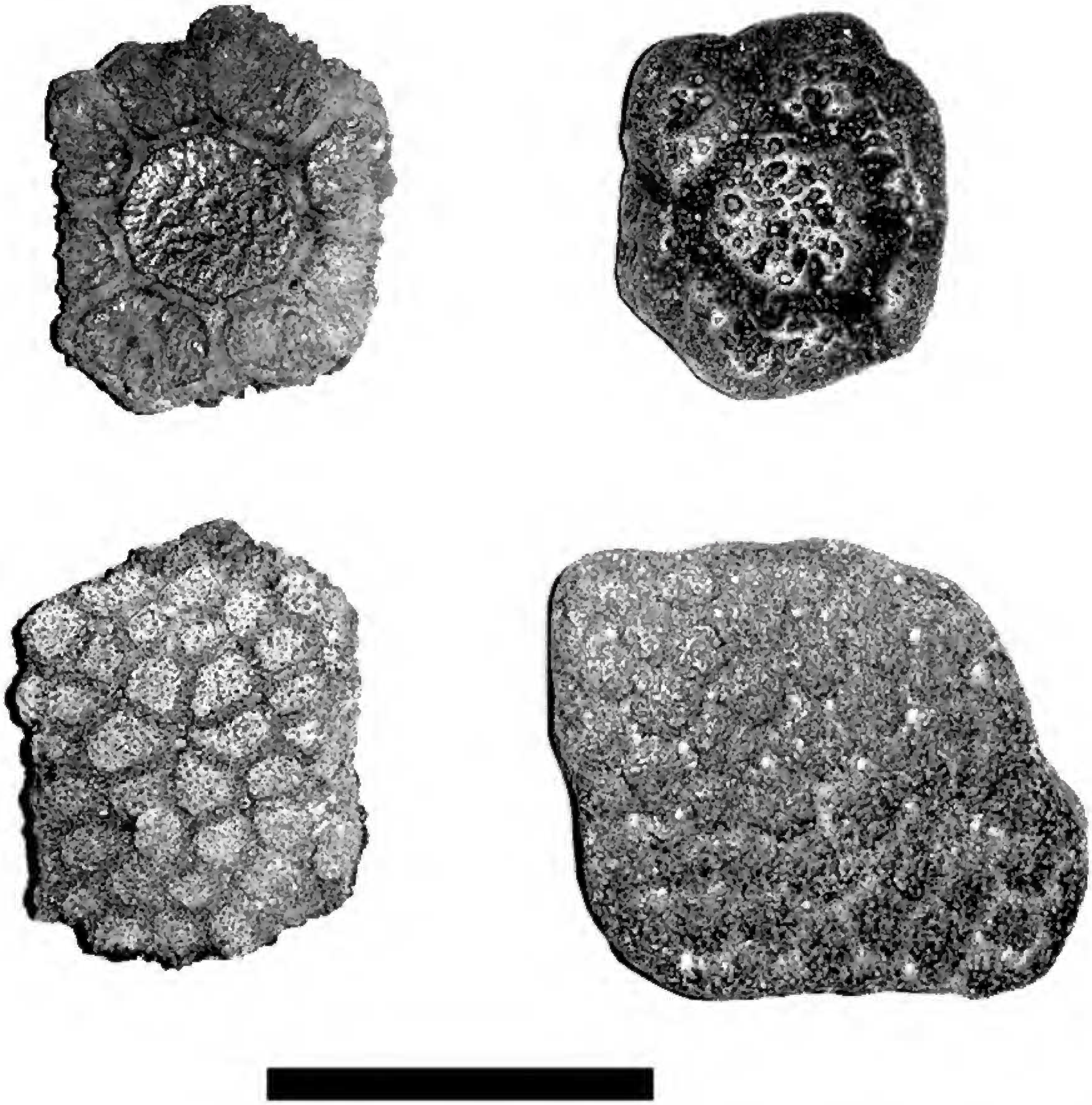


Fig.9- Comparison between fossils from Chuí creek (left) and submarine deposits (right), showing the significant abrasion on the latter. The fossils are osteoderms of *Glyptodon* sp. (top) and *Panochthus* sp. (bottom). Scale bar = 5cm.

Cement

Among the fossils analysed, 45 samples are associated to cement, either embedded in beach rock blocks (Fig.12) or with cavities filled with cement (Fig.13). The cement is carbonatic in origin, precipitated under beach environment warmer climate regime and exhibits recrystallization, which indicates subsequent exposition to freshwater (Buchmann, 2002). In one of the fossils, the recrystallization and subsequent expansion of the calcite crystals caused the fossil to fracture (Fig.14). The cementation of fossils of terrestrial mammals together with very fragmented marine bioclasts suggests that these remains were concentrated together in the past on high-energy beach environment.

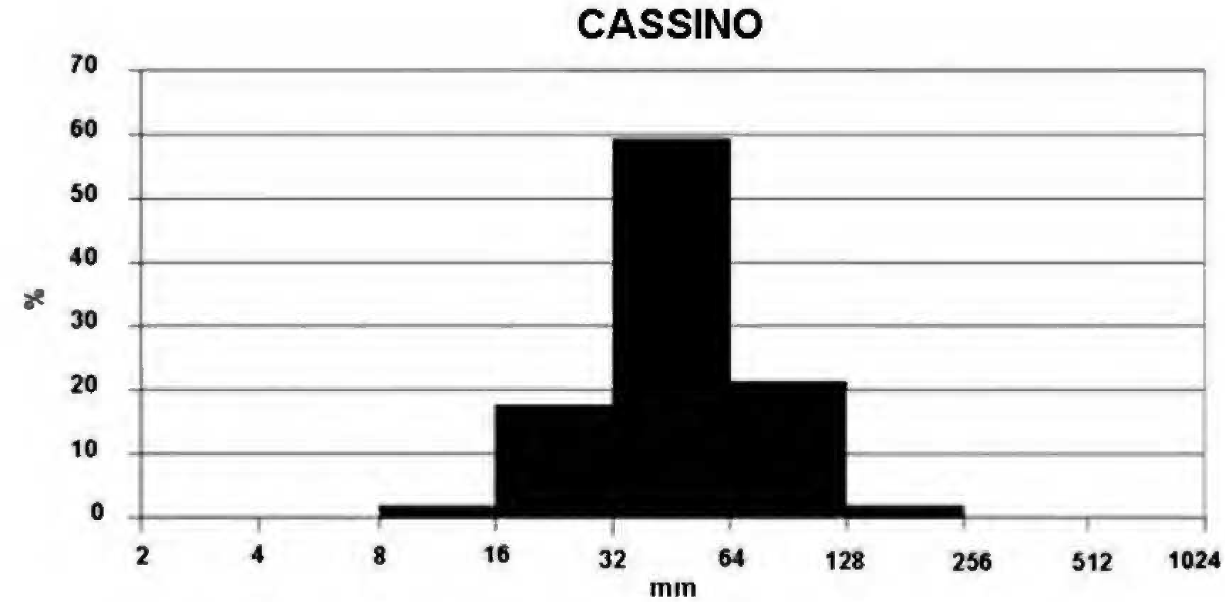
The dissolved carbonate precipitation as cement would be possible only under tropical climate conditions (Stoddart & Cann, 1965), a process that can be observed today in northeastern Brazil (Barros *et al.*, 2003; Guerra *et al.*, 2005). This implies that the climatic conditions at the time of precipitation of the carbonate cement associated to fossils were warmer than the present climate regime in southern Brazil.

The source of the beach rock blocks are rocky topographic highs (parcels and banks), located on the continental platform. These highs are disposed parallel to the coastline as narrow, linear ridges (Figueiredo, 1975), separated from each other by depressions where bioclasts are accumulated. These deposits are regarded as ancient coastlines (Asp, 1999), cemented by carbonate precipitation during events of sea-level stabilization under warmer climate regime. The erosive action of storm waves, mainly during winter, removes blocks from the highs and transport it to the beach. The biofabric of the beach rocks ranges from matrix-supported to bioclasts-supported; the shells range from milimetric-sized, unidentifiable fragments, to bivalves in life position, with valves still closed. The granulometry of the matrix ranges from mud to medium-sized sand grains, and there is also colour variation, from black to reddish. These differences suggest several events of accumulation and cementation of bioclasts, under varying local conditions and episodic storm events.

Colonization

Only eight fossils exhibit its surface colonized by marine organisms (Fig.15). These organisms are representative of diverse taxonomic groups, which have a wide bathymetric distribution. There are no conclusive evidences of the presence of boring organisms, only fouling organisms were observed, such as barnacles, corals, sponges, and bryozoans. The few colonized fossils come from great distance from the coast, at depths more than 50m, outside the influence of waves. None of these fossils ever come to the beach. All the samples were collected by fishing boats with trawls.

Fig.10- Abrasion on bigger fossils. Scale bar = 10cm.



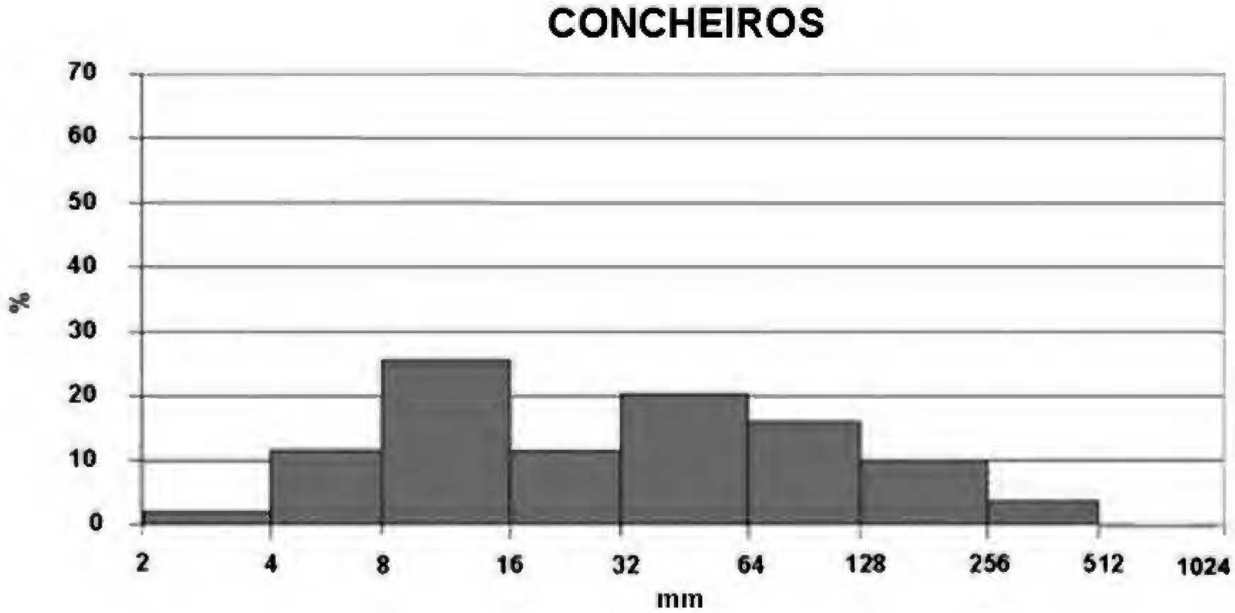


Fig.11- Comparison between sizes (in milimeters) of fossils from Cassino beach and Concheiros (modified from Caron, 2004)

The absence of colonizing organisms in bigger and well-preserved fossils indicate that these remains are covered by sediments in deposits that are only recently being exposed to erosion by marine dynamics; the smaller fossils are not colonized because they are constantly being transported and abraded by wave action in the surf zone.

Since taphonomic features on fossils are determined by physical characteristics of the depositional environment in which were accumulated, differences on preservation among fossils of the same taxonomic groups should reflect the influence of distinct environmental conditions (Speyer & Brett, 1986). The analysis of these features should allow the recognition of specific sedimentary environments, as well as reconstitute the taphonomic history of these remains. Althought re-worked and altered by exposition to marine environment, the fossils from submerged deposits along southern Rio Grande do Sul coast show taphonomic similarities with fossils from Chuí creek deposits. These similarities, as well as the presence of the same taxonomic groups in both deposits, suggest that they share a similar origin, on lacustrine environments in which the fossils were accumulated.

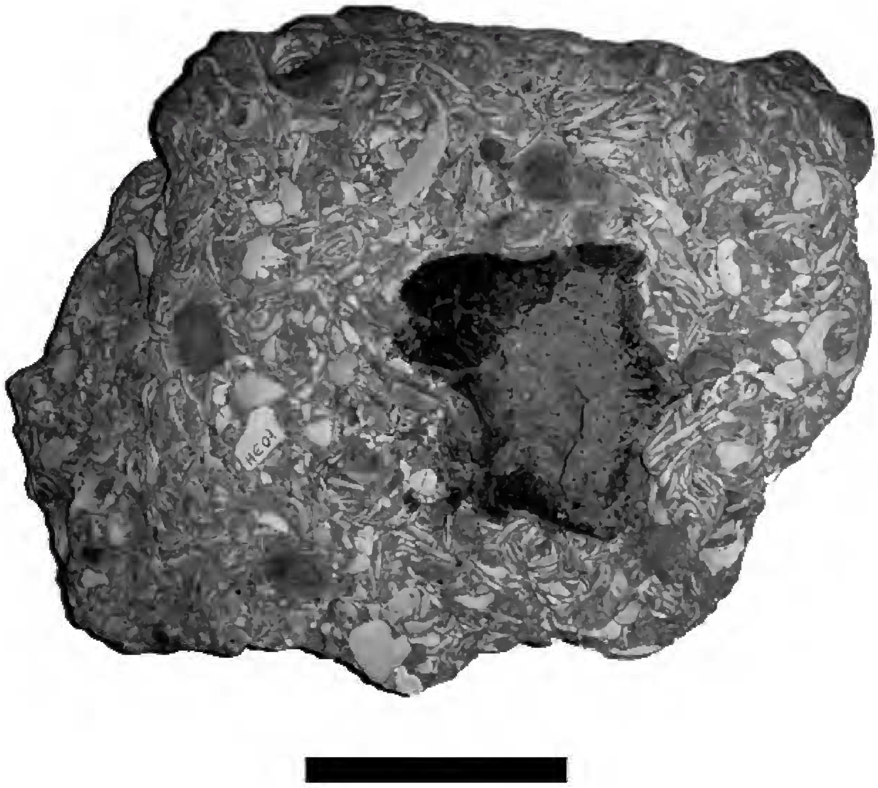


Fig.12- Beach rock with a fossil (in black) embedded on the matrix. Scale bar = 5cm.

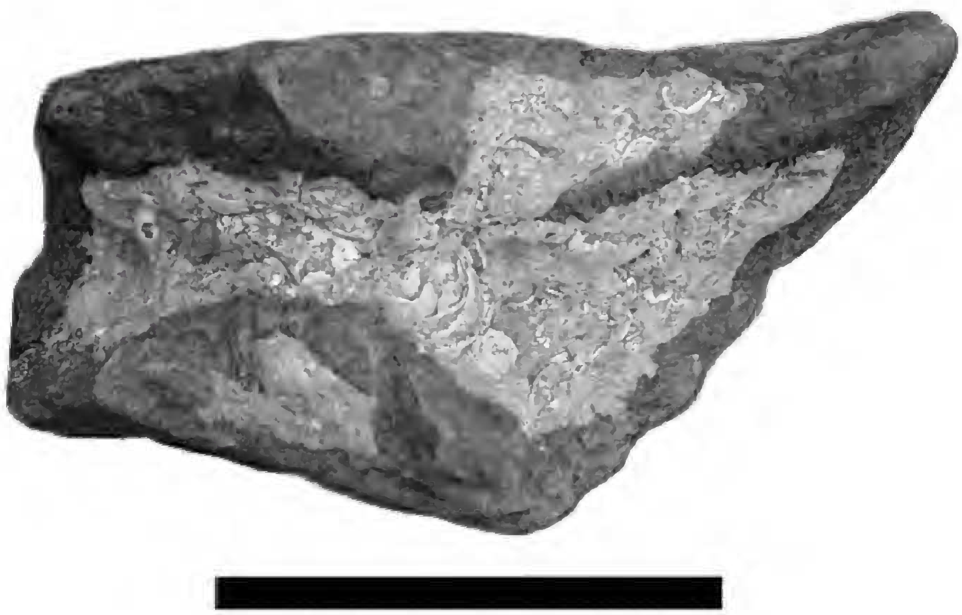


Fig.13- Fossil with cavity filled with carbonate cement. Scale bar = 10cm.

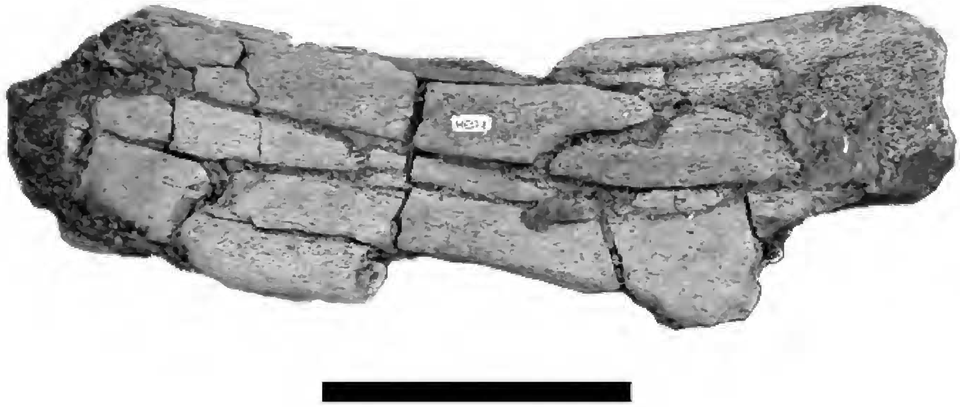


Fig.14- Fossil cracked due to recrystallization and expansion of carbonate cement. Scale bar = 10cm.

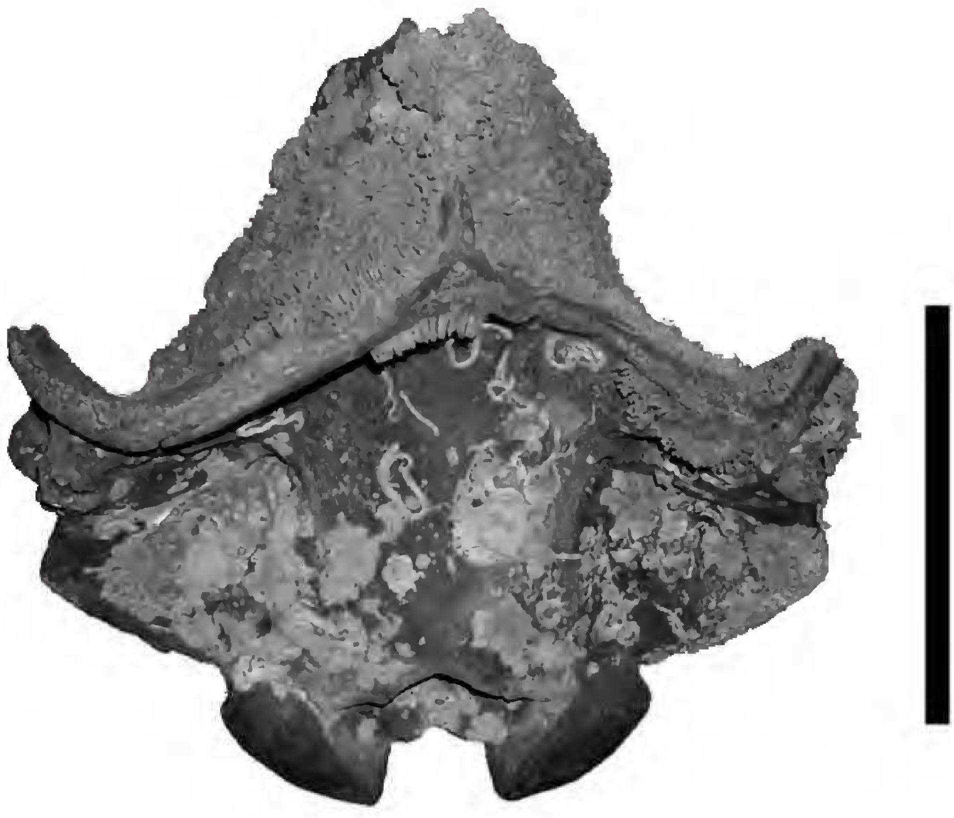


Fig.15- Fossil of a *Toxodon* sp. (occipital portion of skull, in dorsal view) with surface colonization. Scale bar = 20cm.

Subsequently, sea-level transgressions re-worked some of these deposits and its associated fossils. This re-working in marine environment exposed these fossils to new environmental conditions, which resulted in distinct taphonomic features, which allow to divide these remains in three groups:

Group 1: Fossils without cement and/or colonization by marine organisms – In general, the bigger fossils of this group are well-preserved, while the small ones are broken and so much abraded. These fossils can be found associated to shell fragments and fossils of marine organisms (crustaceans, fishes, echinoderms) on the beach, where are thrown by waves during winter storms.

Group 2: Fossils with cement, without colonization – These fossils are either embedded in beach rock blocks or with its cavities filled with cement. The cement is carbonatic and was subject to recrystallization due to subsequent exposition to freshwater. Fossils embedded in beach rock slabs are more rounded and exhibit significant abrasion, which suggest that were subject to intense re-working prior to cementation.

Group 3: Fossils colonized by marine organisms – These fossils have their surfaces colonized by fouling marine organisms such as sponges, corals, bryozoans, and barnacles. These fossils are relatively well-preserved, without abrasion or cement, like fossils from Group 1.

CONCLUSIONS

Althought the fossils from deposits submerged along the coast of Rio Grande do Sul State exhibit some remarkable physical differences (*e.g.*, colour, hardness) in comparison to those from Chuí creek, the overall taphonomic similarities between these remains suggest that both fossil assemblages share a similar origin. The main taphonomic differences are result of the exposition of the former to marine environment. These remains were probably deposited and fossilized in continental environments of Barrier-Lagoon System III, just like the fossils from Chuí creek. Subsequently, sea-level oscillations re-worked those deposits and made its fossil content subject to a new diagenetic process, which caused these remains to become darker and heavier than the fossils from Chuí creek.

The taphonomic variability among fossils from submarine deposits indicates that these remains are preserved in at least three distinct sub-environments along the foreshore and continental platform. In the fossils from Group 1, the absence of surface colonization suggests that these remains are covered by sediment until its removal and transport to the beach. The general good preservation of these remains indicates that they spend a short time under direct wave action, from the removal to transport to the beach. The presence of fragile seabird fossils from these deposits (Lopes *et al.*, 2006) seems to corroborate this. Therefore, the submerged deposits from where they come are biodethrithic concentrations located near the shoreline, which are being re-worked by erosive processes observed today along Rio Grande do Sul coast (Dillenburg *et al.*, 2004). The fossils from Group 2 come from rocky deposits that were originated by carbonate precipitation under warmer climate in paleo-beaches, where were re-worked and concentrated together with shell fragments and fossils of marine organisms, in an environment similar to Concheiros. Subsequent sea-level oscillations exposed these deposits to freshwater, which caused the carbonatic cement to recrystallize. The lack of surface colonization by marine boring organisms (*e.g.*, sponges, corals) suggests that these remains are being subject to direct and constant wave action today. Fossils from Group 3 are the most scarce among the samples, due to the fact that they are never thrown onto the beach by wave action, but are often brought to surface by trawlers from depths between 20 to 150m, in areas called "graveyards" by fishermen. The good preservation suggest that these fossils are not being subject to re-working by waves today, and the presence of fouling organisms indicate that they are not covered by sediment.

The concept of taphofacies can be defined as a sedimentary rock recognized by a specific set of preservation features on the fossils contained on it (Holz & Simões, 2002). Thus, the biostratinomic variations observed among fossils from submarine deposits can be interpreted as result of differential preservation of these remains, therefore allowing the recognition of at least three submarine taphofacies to which these fossils are associated: Taphofacies 1 – characterized by well-preserved fossils that have been recently exposed to marine environment, due to its removal from deposits near the present beach that are being subject to erosion; Taphofacies 2 – contains fossils with recrystallized carbonate cement and evident signs of abrasion and cracking, due to exposition and re-working on a beach environment in the past; and Taphofacies 3 – characterized by well-preserved fossils, similar to those of Taphofacies 1, but are colonized by fouling organisms such as barnacles, sponges and corals.

The association of fossils of terrestrial mammals to remains of marine organisms in the same depositional environment on the past (as evidenced by fossils cemented together with marine bioclasts in beach rocks) and at the present (at the Concheiros), and the varying degrees of preservation of these remains, suggest that sea-level oscillations have been cyclicaly re-working fossiliferous continental deposits of Barrier-Lagoon System III throughout the Pleistocene and Holocene.

The present work is the first detailed description of taphonomic features on fossils of terrestrial mammals from deposits submerged along Rio Grande do Sul coast. Additional and more detailed research, employing other methods such as hydroacoustic soundings, autonomous diving, and petrological and geochemical analyses on the fossils should provide information about the origin, extension, and geometry of the submerged fossiliferous deposits, their stratigraphical context, and the nature of the diagenetic modification on these fossils. The data presented here, together with stratigraphical, geochemical and sedimentological data, should allow the detailed reconstitution of the taphonomic history of the fossil remains fom these deposits. This will allow to assess the physical processes responsible for the origin of the fossiliferous deposits, which will improve our knowledge regarding the origin and evolution of Rio Grande do Sul coastal plain.

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